$\mathcal{H}$-matrix Fast Direct Solution of Scattering Problems with Locally Corrected Nyström Discretized Combined Field Integral Equation

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High-order (HO) solution of the electrically large scattering problems has been critically important in many practical applications such as development of stealth technologies, electromagnetic compatibility (EMC) analysis of the systems mounted on electrically large platforms, and wireless channel modeling in 5G communication networks. Due to large electrical sizes of the involved models, discretization of the surface integral equations (SIEs) is a popular method due to localization of the unknown surface currents to the boundaries of the object. The accurate solution of such problem can be obtained through HO discretization using the Locally Corrected Nyström (LCN) method or the higher-order Method of Moments (MoM). Unlike the MoM discretization where the interactions are defined between the elements of the mesh, the LCN discretization is a point-based. Hence, the HO LCN solution can be obtained more efficiently.

The conventional LCN discretization of SIEs result in dense matrix equations. Therefore, the overall solution become prohibitively expensive in terms of required CPU time and memory when number of DoFs is large. Hence, the sophisticated iterative and direct fast algorithms must be used to accelerate the solution of such practically interesting problems. On the other hand, the discretization of the traditional SIEs for the objects featuring complex geometry often produce poorly conditioned matrix equations. For that reason, the iterative fast methods such as Multi-Level-Fast-Multipole-Algorithm (MLFMA) and pre-corrected Fast Fourier Transform (p-FFT) often suffer from poor convergence. However, the fast direct algorithms based on hierarchical ($\mathcal{H}$)-matrices (W. Hackbusch, Computing, 62, 89–108, 1999) are not as susceptible to the poor conditioning of the pertinent matrix.

In this work, a fast direct HO-LCN discretization of the combined field integral equation (CFIE) is proposed for scattering problem on perfect electric conductor (PEC) featuring smooth and complex geometries. The method is based on the error-controlled $\mathcal{H}$-matrix formation with a significantly reduced computational cost. The proposed scheme features fast direct based $\mathcal{H}$-LU decomposition of the resultant matrices followed by the back-substitution while maintaining the HO performance of the conventional LCN method. Numerical results validate the HO error behaviour in the proposed computational framework. The error performance and the computational complexity of the proposed method will be presented at the symposium for various scattering problems.